CLAIMS

1. A process for the production of synthesis gas ("syngas") comprising carbon monoxide and molecular hydrogen, said process comprising;

exothermically reacting hydrocarbon-containing fuel with an oxidant gas comprising molecular oxygen in a first reactor to produce an exothermically-generated syngas product;

combining a stream of reactive diluent fluid with a stream of said exothermically-generated syngas product to produce a reactive mixture;

reacting said reactive mixture in a second reactor to produce a reacted syngas product; and

endothermically reforming hydrocarbon-containing fuel gas with steam over a catalyst in a heat exchange reformer to produce a heat exchange-reformed syngas product,

wherein at least a portion of the heat required in the generation of said heat exchange-reformed syngas product is obtained by recovering heat from said reacted syngas product thereby cooling said reacted syngas.

2. The process as claimed in Claim 1 wherein said heat exchange-reformed syngas product is combined with said reacted syngas product prior to heat recovery.

3. The process as claimed in Claim 1 or Claim 2 wherein the reactive diluent fluid controls the temperature of the exothermically-generated syngas product.

4. The process as claimed in any of Claims 1 to 3, wherein the oxidant gas consists of molecular oxygen.

5. The process as claimed in any of Claims 1 to 4, wherein the hydrocarbon fuel is reacted with the oxidant gas in the presence of water.

6. The process as claimed in any of Claims 1 to 5, wherein the reactive mixture comprises carbon dioxide, at least a portion of which is reacted together with at least a portion of the molecular hydrogen in said reactive mixture over a catalyst in a reverse water gas shift reaction zone in the second reactor to produce a carbon monoxide-enriched syngas product.

7. The process as claimed in any of Claims 1 to 6, wherein the reactive mixture comprises solid carbon particles, at least a portion of which is gasified by reaction with at least one other component of the reactive mixture in a gasification zone in the second reactor to produce a solid carbon-depleted syngas product.

8. The process as claimed in any of Claims 1 to 7, wherein the reactive diluent fluid is a gas thereby cooling the exothermically-generated syngas product *via* sensible heat exchange.

9. The process as claimed in any of Claims 1 to 7, wherein the reactive diluent fluid is a liquid thereby cooling the exothermically-generated syngas product *via* vaporisation and sensible heat exchange.

10. The process as claimed in any of Claims 1 to 9, wherein the reactive diluent fluid is recovered and recycled from downstream processing of syngas.

11. The process as claimed in any of Claims 1 to 10, wherein the reactive diluent fluid comprises carbon dioxide.

12. The process as claimed in Claim 11 wherein the reactive diluent fluid comprises carbon dioxide separated and recycled from downstream syngas.

13. The process as claimed in Claim 11 wherein the reactive diluent fluid comprises the products of a combustion process.

14. The process as claimed in Claim 13 wherein the combustion products are selected from the group consisting of combustion furnace flue gases and gas turbine exhaust gas.

15. The process as claimed in Claim 11 wherein the reactive diluent fluid comprises carbon dioxide imported from an external source.

16. The process as claimed in any one of the preceding claims wherein the reactive diluent fluid further comprises a component selected from the group consisting of methane and other hydrocarbon(s).

17. The process as claimed in any of the preceding claims, wherein the reactive diluent fluid comprises molecular hydrogen.

18. The process as claimed in any of the preceding claims wherein the reactive diluent fluid comprises water.

19. The process as claimed in Claim 18 wherein the water is in the form of liquid water.

20. The process as claimed in Claim 18 wherein at least a portion of the water is in the form of steam.

21. The process as claimed in any of the preceding claims wherein the heat exchange-reformed syngas product or a syngas mixture derived therefrom is used in a downstream conversion process to produce conversion products selected from the group consisting of hydrocarbon liquid fuels, methanol, DME and oxo-alcohols.

22. The process as claimed in any of the preceding claims further comprising combining a second diluent fluid with a syngas stream between the point at which the reactive diluent fluid is combined with said exothermically-generated syngas product and the point at which heat is recovered from the reacted

syngas product to adjust the temperature and/or change the composition of relevant syngas stream.

23. The process as claimed in Claim 22 wherein the second diluent fluid is combined with the reactive mixture in any section of the second reactor.

24. The process as claimed in Claim 22 wherein the second diluent fluid is combined with the reacted syngas product at any point between the second reactor and the heat exchange reformer or, where the heat exchange reformer is a shell and tube style reformer in which the endothermic reforming reaction occurs within the tubes and the reacted syngas product is introduced to the shell-side, in any section of the shell-side of the heat exchange reformer.

25. The process as claimed in Claim 24 comprising combining molecular hydrogen as the second diluent fluid with the reacted syngas product to enhance the heat exchange efficiency inside the heat exchange reformer.

26. The process as claimed in Claim 24 comprising combining water and/or steam as the second diluent with the reacted syngas product to reduce the amount of metal dusting inside the heat exchange reformer and/or to adjust the temperature of the reacted syngas product.

27. The process as claimed in any of Claims 22 to 24 wherein the second diluent fluid is inert.

28. The process as claimed in any of Claims 22 to 24 wherein the second diluent fluid is selected from the group consisting of water vapour, steam, liquid water, molecular hydrogen, carbon dioxide, methane, other hydrocarbons, off-gas from downstream processes, combustion furnace flue gases and gas turbine exhaust gas.

29. A process for the production of syngas comprising carbon monoxide and molecular hydrogen, said process comprising;

exothermically reacting hydrocarbon-containing fuel with an oxidant gas comprising molecular oxygen in a first reactor to produce an exothermically-generated syngas product;

cooling an effluent stream of said exothermically-generated syngas product by combining reactive diluent fluid with said stream to produce a mixture comprising cooled exothermically-generated syngas product and reactive diluent fluid, said mixture further comprising at least one component selected from the group consisting of carbon dioxide and solid carbon particles;

said process further comprising:

reacting together carbon dioxide in said mixture with molecular hydrogen in said mixture over a catalyst in a second reactor to produce reacted syngas product that is enriched in carbon monoxide; and/or

gasifying solid carbon particles in said mixture with at least one other component in said mixture in a second reactor to produce reacted syngas product that is depleted in solid carbon.

30. The process as claimed in Claim 29 wherein the reacted syngas product is both enriched in carbon monoxide and depleted in solid carbon.

31. A process as claimed in Claim 29 or Claim 30 further comprising endothermically reforming hydrocarbon-containing fuel gas with steam over a catalyst in a heat exchange reformer to produce heat exchange-reformed syngas product wherein at least a portion of the heat generated in the exothermic reaction producing said first syngas product is used to drive the endothermic reforming reaction.

32. A process substantially as hereinbefore described with reference to the accompanying figures.

33. Apparatus for the production of syngas comprising carbon monoxide and molecular hydrogen according the process defined in Claim 1, said apparatus comprising:

a first reactor in which hydrocarbon-containing fuel is reacted exothermically with an oxidant gas comprising molecular oxygen to produce an exothermically-generated syngas product;

conduit means for removing an effluent stream of said exothermically-generated syngas product from the first reactor;

means for combining a stream of reactive diluent fluid with said effluent stream to produce a reactive mixture;

a second reactor in which said reactive mixture reacts to produce a reacted syngas product;

a heat exchange reformer in which hydrocarbon-containing fuel gas is reformed endothermically with steam over a catalyst to produce a heat exchange-reformed syngas product; and

conduit means for feeding a stream of reacted syngas product from the second reactor to the heat exchange reformer;

wherein at least a portion of the heat required in the generation of said heat exchange reformed syngas product is obtained by recovering heat from said reacted syngas product thereby cooling said reacted syngas product.

34. Apparatus as claimed in Claim 33 wherein the first reactor is selected from the group consisting of a partial oxidation ("POX") reactor, an autothermal reformer ("ATR") and a catalytic partial oxidation ("CPO") reactor.

35. Apparatus as claimed in Claim 33 or Claim 34 wherein the reactive mixture comprises carbon dioxide and the second reactor has a reverse water gas shift reaction zone in which at least a portion of the carbon dioxide and at least portion of the molecular hydrogen in said mixture are reacted together over a catalyst to produce a carbon monoxide-enriched syngas product.

36. Apparatus as claimed in any of Claims 33 to 35 wherein the reactive mixture comprises solid carbon particles and the second reactor has a gasification reaction zone in which at least a portion of the solid carbon particles is gasified by reaction with at least one other component of the mixture to produce a solid carbon-depleted syngas product.

37. Apparatus as claimed in any of Claims 33 to 36 wherein the heat exchange reformer is a shell and tube style reformer in which the endothermic reforming reaction occurs within the tubes and the reacted syngas product is introduced to the shell-side.

38. Apparatus as claimed in any of Claims 33 to 37 wherein the reformer is an enhanced heat transfer reformer ("EHTR").

39. Apparatus as claimed in any of Claims 33 to 38 further comprising means for combining a second diluent fluid with a syngas stream between the point at which the reactive diluent is combined with said exothermically-generated syngas product and the point at which heat is recovered from the reacted syngas product to adjust the temperature and/or change the composition of relevant syngas stream.

40. Apparatus for the production of syngas comprising carbon monoxide and molecular hydrogen according to the process defined in Claim 29, said apparatus comprising:

a first reactor in which hydrocarbon-containing fuel is reacted exothermically with an oxidant gas comprising molecular oxygen to produce an exothermically-generated syngas product;

a second reactor;

conduit means for feeding an effluent stream of said exothermically generated syngas product from the first reactor to the second reactor;

means for combining reactive diluent gas with said effluent stream to produce a mixture comprising cooled exothermically-generated syngas product and reactive diluent gas, said mixture further comprising at least one component selected from the group consisting of carbon dioxide and solid carbon particles;

said apparatus further comprising:

a reverse water gas shift reaction zone in which carbon dioxide in said mixture is reacted together with molecular hydrogen in said mixture

over a catalyst in the second reactor to produce a reacted syngas product that is enriched in carbon monoxide; and/or

a gasification reaction zone in which solid carbon particles in said mixture are gasified with at least one other component in said mixture in the second reactor to produce a reacted syngas product that is depleted in solid carbon.

41. Apparatus as claimed in Claim 40 further comprising:

a heat exchange reformer in which hydrocarbon-containing fuel gas is reformed endothermically with steam over a catalyst to produce a heat exchange reformed syngas product;

conduit means for feeding reacted syngas product from the second reactor to the heat exchange reformer;

wherein at least a portion of the heat generated in the exothermic reaction producing said exothermically generated syngas product is used to drive the endothermic reforming reaction.

42. Apparatus as claimed in any of Claims 33 to 41 wherein the first reactor is a partial oxidation ("POX") reactor and the reformer is an EHTR.

43. Apparatus substantially as herein before described with reference to the accompanying figures.